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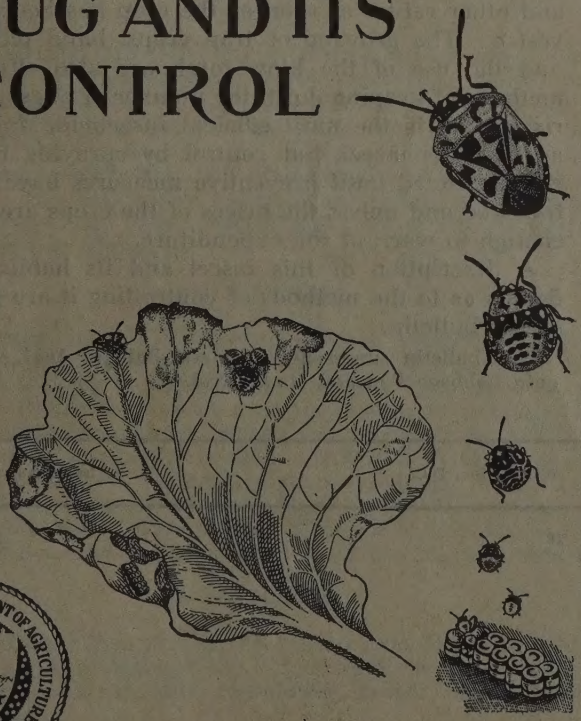
FARMERS' BULLETIN No. 1712

The HARLEQUIN BUG AND ITS CONTROL



1933

THE HARLEQUIN BUG is a serious pest of cabbage and related crops in the Southern States. It sucks the sap from the leaves and causes them to wilt and, if the plants are young, to die.

The pest can best be controlled by practicing clean cultural methods throughout the season, and especially by disking and plowing-under all stalks and other refuse as soon as the crop has been harvested. The growing of trap crops, hand picking, and the use of the blow torch are also effective methods of keeping down the number of bugs. Derris extract is the most efficient insecticide for use against this insect, but control by spraying is not recommended until preventive measures have been followed and unless the prices of the crops are high enough to warrant the expenditure.

A description of this insect and its habits and details as to the methods of controlling it are given in this bulletin.

This bulletin supersedes Farmers' Bulletin 1061, Harlequin Cabbage Bug and Its Control.

Washington, D.C. Issued August 1933

THE HARLEQUIN BUG AND ITS CONTROL

By W. H. WHITE, *principal entomologist, and* L. W. BRANNON, *assistant entomologist, Division of Truck Crop and Garden Insects, Bureau of Entomology*[1]

B.P.I.

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THE HARLEQUIN BUG has long been a serious pest of cabbage and other crucifers in the southern part of the United States. This brilliantly colored red and black plant bug sucks the sap from the leaves and veins of the plants, causing them to wilt and wither and many of them to die. Severely injured plants appear as though they had been swept by fire, thus giving the insect the popular name "fire bug." It is also known variously as "calico back", "terrapin bug", "cabbage bug", and "collard bug", and to scientists as *Murgantia histrionica* Hahn.

DISTRIBUTION

The harlequin bug is a native of Central America and Mexico. It was first recorded in the United States in Washington County, Tex., in 1864. This appearance was followed by a rapid eastward and slower northward spread over the South, approximately the northern limits for normal damage being reached by 1870. The insect has been found as far north as southern South Dakota, southeastern Iowa, southern Wisconsin, southern Michigan, northern Ohio, northern Pennsylvania, western New York, Connecticut, and Massachusetts, but it is not a pest of economic importance in the Northern States, probably on account of adverse climatic conditions.

FOOD PLANTS

The harlequin bug is primarily a pest of crucifers and readily attacks such plants as cabbage (fig. 1), mustard, turnip, collards (fig. 2), rutabaga, broccoli, kale, cauliflower, radish, chinese cabbage,

[1] In cooperation with the Virginia Truck Experiment Station, Norfolk, Va.

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horseradish, brussels sprouts, kohlrabi, and rape. Under extreme conditions, such as lack of normal food and heavy infestations, the pest has been known to attack squash, corn, beans, and other vegetable crops not belonging to the same plant family as cabbage. It also feeds and breeds on wild mustard, shepherds-purse, peppergrass, bittercress, rockcress, watercress, sea rocket, bee plant, and practically all other plants of the mustard family.

NATURE OF INJURY

The harlequin bug has sucking mouth parts and obtains its food by piercing and sucking the juices from the leaves and stems of the plants on which it feeds. Shortly after the feeding, white areas or

FIGURE 1.—Cabbage plant showing typical harlequin-bug injury. Some of the leaves are wilted and others show the characteristic white feeding areas.

blotches appear about the spots where the insect has punctured the plant tissue (fig. 1). When the insect is abundant and attacks young plants, they soon wilt, turn brown, and die. If larger plants are fed on, stunted growth is often the result (fig. 2).

THE DIFFERENT STAGES

The harlequin bug has a very distinctive appearance. It is brilliantly colored and strikingly marked with red or yellow and either black or deep blue. The adult is about half an inch long, flat, and shield-shaped (fig. 3, A).

The eggs are about one twenty-fifth of an inch long. They are pearl gray or pale yellow in color, with two black bands, one near

FIGURE 2.—Field of collards showing plants injured by the harlequin bug in the foreground as compared with uninjured plants in adjacent rows. Note wilting and stunting of the injured plants.

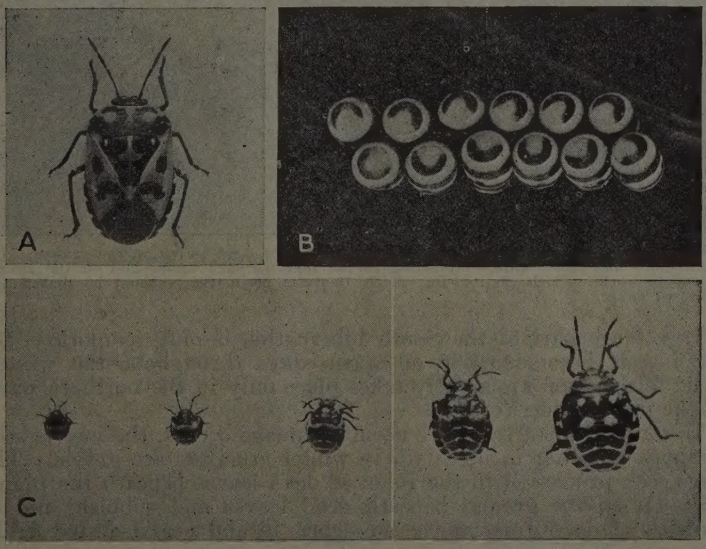

FIGURE 3.—A, Adult harlequin bug; B, eggs; C, first to fifth nymphal stages. Eggs about 9 times natural size; nymphs about 2½ times natural size; adult about twice natural size

the top and the other near the bottom, and with a small black spot just above the lower band. They have the general appearance of small black-banded barrels (fig. 3, B).

The immature stages, or nymphs, are similar to the adults in appearance, except that they are smaller and lack wings. As the young nymph grows, it molts or sheds its skin, passing through five stages before becoming full grown (fig. 3, C).

OVERWINTERING

Throughout most of its range the harlequin bug lives through the winter in the adult stage. As far north as eastern Virginia, during exceptionally mild winters, eggs, nymphs, and adults have been found in the field in February, and farther south the insect may be active during the entire winter.

FIGURE 4.—Collard plants, showing an accumulation of dead leaves on the ground. The harlequin bug seeks winter protection in the folds of such leaves and on the ground beneath them. Such plants, for which there is no market, should be disked and plowed under.

In a large part of the South hibernation is only temporary, for the insects become active on warm days throughout the winter. True hibernation apparently takes place only in the northern parts of the infested territory.

In most of the area where normal damage occurs, the insects seek temporary shelter in fields where winter crucifers are grown. The bugs seek protection in the folds of dead leaves beneath the plants (fig. 4), on the ground beneath dead leaves and rubbish, and in bunches of dead grass and other debris in and near infested fields.

LIFE HISTORY

Usually in the early spring the insects leave winter quarters, and all stages may be found in the field during the entire growing season. About 15 days after becoming active in the spring, the adult female begins depositing eggs on the lower surfaces of leaves. The eggs are deposited in double rows of from 10 to 13, 12 being the usual number. A female may lay an egg mass every 5 or 6 days. It has been observed that as many as 187 eggs have been deposited by a single female, while the average number was 115.

Eggs laid in the early spring usually hatch in 15 to 20 days. As the weather becomes warmer the eggs hatch after 4 or 5 days. After hatching, the young, or nymphs, remain congregated about the eggshells for 24 to 36 hours before beginning to feed. In the early spring the complete development from egg to adult may require between 60 and 70 days. In midsummer this period is shortened to between 40 and 60 days. The female deposits eggs within 2 or 3 weeks after becoming full grown.

Some of the individuals that overwintered may live 120 days, but the majority die after about 60 days. The bugs that overwintered usually live longer and deposit more eggs than those of the generations that develop within the active season. The egg-laying period for females that pass the winter ranges from 40 to 80 days.

In most of its range two generations and a partial third occur. Late in the fall, activity is retarded, and general feeding usually ceases by the time of the first frost.

NATURAL ENEMIES

The harlequin bug is remarkably free from parasites and predacious insects. No internal parasite of the insect has been recorded. There are three known parasites of the eggs, *Trissolcus murgantiae* Ashm., *Trissolcus podisi* Ashm., and *Ooencyrtus johnsoni* How.; but, so far as has been observed, they have never become abundant enough throughout the infested territory to serve as a natural means of control of this pest. One of these, *O. johnsoni*, however, appeared to be of considerable value in eastern Virginia during the unusually severe harlequin-bug outbreak of 1932. This parasite was first recorded in eastern Virginia in September 1931, although it had no doubt been present for some time previously. In 1932 it was reared from harlequin-bug eggs collected in the field from the first part of July to the middle of September. During the latter part of August approximately 50 percent of the eggs in some fields were parasitized. As many as three of the minute parasites have been observed to develop in one harlequin-bug egg. It is possible that under favorable conditions this parasite may prove to be highly beneficial in some parts of the South.

One predacious insect, the wheel bug (*Arilus cristatus* L.), has been recorded as feeding on young harlequin-bug nymphs, and another, the leaf-footed bug (*Leptoglossus phyllopus* L.), is recorded as destroying the adult, but these are of slight importance as a means of natural control.

METHODS OF CONTROL

For best results in the treatment of the harlequin bug, preventive measures are necessary, as this insect is exceedingly difficult to combat after it has become numerous on its host plants.

CULTURAL METHODS

The value of clean farming in insect control has long been recognized. This is especially true in connection with the harlequin bug. Crop remnants are often left in the field for some time after harvesting. This is a bad practice, as the insects continue to breed and develop is such fields and easily move over to uninfested plantings nearby. In some sections of the South growers usually leave portions of the kale, and less frequently other cruciferous crops, for the production of seed. They sow these crops during the late summer of one season and gather the seed about the middle of the following season. After gathering the seed, they frequently leave the

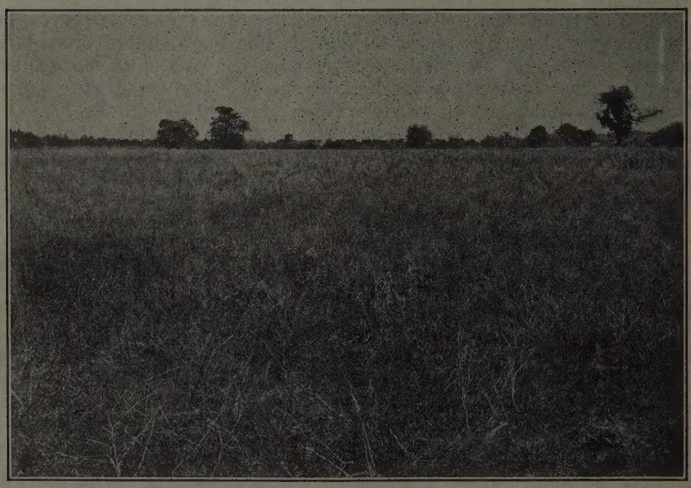

FIGURE 5.—Field of kale abandoned during the winter and left to grow up in weeds. The majority of the plants have dried up, but live sprouts are still plentiful. Large populations of harlequin bugs develop in fields such as this, and when food becomes scarce the adults fly and the nymphs crawl to young crucifers on adjacent farms.

stalks standing and desert the fields. When prices do not justify harvesting, large acreages of these crops are often abandoned during the winter and spring months, and the fields are allowed to grow up in weeds during the remainder of the season (fig. 5). These practices offer ideal conditions for the development and dispersal of the harlequin bug, as the adults that have sought temporary shelter in and near the fields during the winter remain to breed unmolested during the spring and summer. During midsummer, when food becomes scarce in such fields, the adults fly and the nymphs (or wingless forms) crawl (fig. 6) in large numbers to adjacent fields of young crucifers. Severe infestations on adjoining farms are often traced to such sources.

After a commercial crop or one grown for seed has been harvested, or when prices do not justify harvesting, all stalks, plant remains, and other refuse should immediately be disked and plowed under. In cases where cruciferous crops are left in the fields of abandoned farms, cooperative destruction by neighboring growers is highly desirable.

Crawling or migrating nymphs usually enter on one side of a field and attack the plants row by row (fig. 6). When the insects are seen massed on a few rows, its is advisable to disk and plow the heavily infested portions and thus destroy large numbers of the bugs before they are able to do serious damage. It is then important

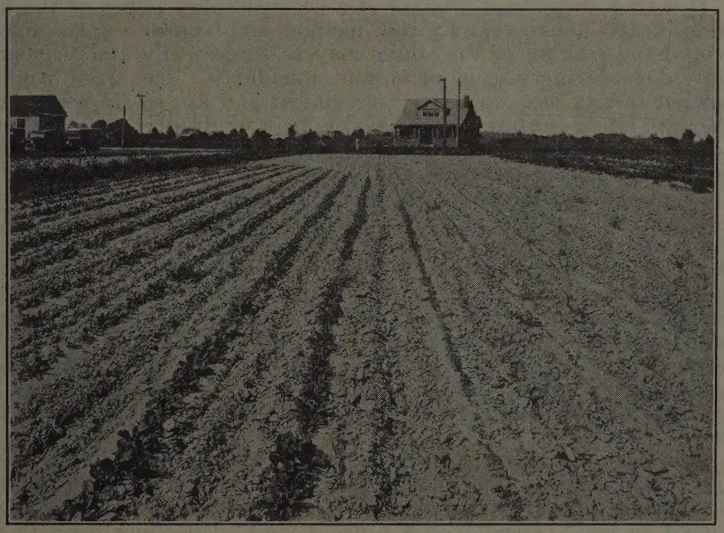

FIGURE 6.—Patch of young chinese cabbage practically destroyed by migrating harlequin-bug nymphs. The nymphs have crawled to this patch from a neighboring abandoned field of crucifers and are destroying the plants row by row.

to locate the breeding grounds (fig. 5) and destroy them in the same manner.

Wild plants of the mustard family should be carefully kept down throughout the year. A list of such plants is given on page 2.

TRAP CROPS

The growing of trap crops in harlequin-bug control has been practiced for many years. If properly handled, very good results may be obtained by this method. These crops should be planted so that they will be available to the bugs before and after the main crop, the object being to attract the overwintering forms in the spring before the main crop is available and in the fall to concentrate the bugs on a small area. In the spring such plants as mustard, rape, and kale may be utilized as trap crops. They should be planted very early in order to attract the insects from the time they become active until the egg-laying period is over.

In the fall a special trap crop may be planted if all other crops have been harvested and the fields cleaned, or a part of the main crop may be left in the field for this purpose. Since the trap crop must be destroyed to kill the insects, parts of it should be planted on different dates so that a constant food supply will be available.

Trap crops should never be used unless careful attention can be given to destroying the bugs congregated on them. If not properly handled, a trap crop will only serve as a means of breeding more of the insects and thus the purpose for which it was grown will be defeated.

HAND PICKING

If a trap crop is not used, or if a considerable number of the insects escape destruction by this method and appear on the main crop, hand picking of the adults may be successfully and economically done during seasons of normal abundance. The large bright-colored insects seem to scorn concealment and are so sluggish that they are easily captured. The insects may be dropped into buckets containing a small quantity of kerosene, or into fruit jars, from which they may be removed and burned.

An example of the ease with which this insect may be hand-picked is taken from the records at Norfolk, Va., during the spring of 1931. From April 13 to May 4 adult harlequin bugs were hand-picked daily in a 0.14-acre patch of broccoli. During this period, 1,288 bugs, or approximately 9,200 per acre, were gathered and destroyed. Since the insects tend to congregate in scattered sections of a field, individual plants were not closely examined unless one or more bugs were seen crawling about. In this case a thorough examination usually revealed the presence of additional bugs. In this manner it was possible to examine two rows at a time, and to cover an acre in about 7 hours.

Every effort should be made to stamp out an infestation before egg laying begins. The insects usually feed for about 2 weeks in the spring before depositing eggs. During this period the bugs should be hand-picked 2 or 3 times a week, depending upon their abundance, and thereafter as often as is necessary to keep the crop practically free of the pest. When bugs are found on a plant, the under surfaces of the leaves should be examined, and any eggs present should be destroyed by crushing. Any heavily infested plants on which the young, or nymphs, are found should be pulled up and destroyed.

Hand picking should be done during the warmest part of the day. At temperatures below 60° F. the activity of the insects is retarded, and many of them seek temporary shelter in the folds of dead leaves or other debris beneath the plants.

THE HAND TORCH

A plumber's blowtorch has proved to be an aid in controlling the harlequin bug. Its chief value is in destroying the insect on trap crops, although an experienced operator may safely apply it to a garden or commercial field of the more hardy cole crops such as cabbage and collards. An instant's contact with the hot flame will so injure the bugs, by scorching the legs and antennae or "feelers", as to render them harmless and incapable of recovery. The brief contact necessary to accomplish this will not appreciably injure the plant.

In some sections growers use torches made by wrapping an old cloth about the end of a stick and then saturating the cloth in kerosene. Torches have also been made from pine knots.

CONTACT INSECTICIDES

Since the harlequin bug is a sucking instead of a chewing insect, stomach poisons have no effect upon it. In order to kill the insects a contact insecticide must be used and the bugs must be thoroughly covered with the material. This is an extremely difficult task, because the plants upon which the insects feed usually attain such a dense growth that it is practically impossible to reach the insects on all parts of the plant. In some sections of the South where turnips and mustard are sown broadcast for greens an insecticide application is impracticable.

A large number of insecticides have been tested to determine their effectiveness against the harlequin bug.[2] Several of these materials gave excellent results in cage tests, but were found to be inefficient under field conditions. The best results were obtained with derris extract (containing rotenone as the active ingredient and a spreader or wetting agent) at a dilution of 1 to 200.[3] This may be prepared as follows: Use 2 quarts of derris extract in 100 gallons of water or, in smaller quantities, 2 ounces (4 tablespoonfuls) in 3 gallons of water. Measure the quantity of derris extract required to make a given quantity of finished spray, and thoroughly dissolve this in a little water. Then add the dilute derris extract to the quantity of water needed for the finished spray. Agitate the mixture and apply immediately. Mix only sufficient spray for immediate use.

Preliminary tests indicate that commercial dusting powders containing approximately 0.5 percent of rotenone are also of value in controlling the harlequin bug.

It should be borne in mind that only those insects actually hit by the spray are killed. Thoroughness of application is of prime importance.

In treating large crucifers with a hand sprayer it is usually necessary to spray from each side of the row. After thoroughly wetting all visible bugs, it is well to direct the spray to the ground near the base of the plants, as the mechanical motion of the spray rod among the leaves often knocks a few of the insects off the plants.

Control by spraying should be resorted to only after preventive measures to reduce the numbers of the insects have been taken, and when high prices of the crops warrant the expenditure.

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[2] Among the insecticides tested were Japanese-beetle formula sodium oleate-oleoresin of pyrethrum (made in accordance with the method given in U.S. Dept. Agr. Circ. 280, Contact Sprays for the Japanese Beetle), sodium oleate with different proportions of pyrethrum extract, pyrethrum-extract soap with 40 percent nicotine sulphate, several commercial brands of pyrethrum extract, pyrethrum extract with oils, pyrethrum extract with 40 percent nicotine sulphate pyrethrum dust, 40 percent nicotine sulphate, 40 percent nicotine sulphate with activators, nicotine tannate, 40 percent nicotine sulphate with whale-oil soap, 40 percent nicotine sulphate with oils, nicotine oleate, kerosene-nicotine oleate, nicotine-potassium oleate, sodium hydroxide and soap, several commercial brands of white and yellow soaps (with and without 40 percent nicotine sulphate) at strong dilutions, calcium cyanide dust, barium, calcium, and sodium fluosilicates as dusts and sprays, cryolite, sodium fluoaluminate), derris extract at dilutions of 1 to 200 to 1 to 1,200, derris extract at various dilutions with 0.5 percent, 1 percent, and 2 percent soap solutions, and derris extract with whale-oil soap. Derris extract was used in a small series of experiments with white-oil emulsion, summer-strength oils, and tannic acid, and with spreaders.

[3] Entomologists of the Virginia Truck Experiment Station have also obtained very good results with this spray.

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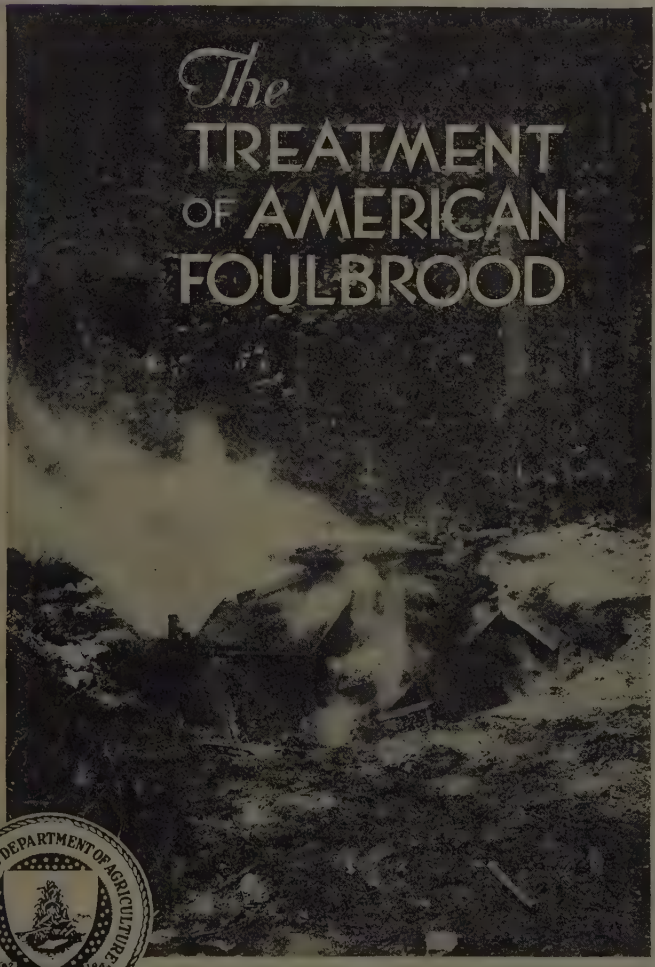
U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1713

The TREATMENT OF AMERICAN FOULBROOD



1913

AMERICAN FOULBROOD is a disease of the brood of bees which causes serious losses to beekeepers. Its occurrence is practically world-wide, it attacks all races of bees, and strong colonies are as liable to infection as weak ones.

It is important that the beekeeper recognize the symptoms of the disease and be familiar with the manner in which it is spread, in order that he may take precautions to keep it out of his apiary and to prevent it from spreading from one colony to another in case any of his colonies become infected. He should also know how to treat the disease in the most effective way. Such information is given in this bulletin. It is impossible to manipulate colonies so that they cannot contract the disease, but much worry and financial loss can be avoided by dealing promptly and effectively with the disease as soon as it appears.

Samples of brood suspected of being diseased are diagnosed free of charge by the Division of Bee Culture, Bureau of Entomology, United States Department of Agriculture, Washington, D.C.

This bulletin supersedes Farmers' Bulletin 1084, entitled "Control of American Foulbrood."

Washington, D.C. Issued October 1933

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THE TREATMENT OF AMERICAN FOULBROOD

By JAS. I. HAMBLETON, *senior apiculturist, in charge, Division of Bee Culture, Bureau of Entomology*

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AMERICAN FOULBROOD is a disease of the brood of bees which causes series losses to beekeepers. Not only does it take a heavy toll in the actual destruction of colonies and increase the cost of operating an apiary, but, what is perhaps of equal importance, the presence of disease in an apiary, or in the vicinity of one, causes such mental anxiety to some beekeepers that it unquestionably prevents them from succeeding in the bee industry.

The disease is practically world-wide in its distribution and is of common occurrence in the United States. All races of bees are susceptible. There have been statements in the beekeeping literature that lead one to believe that the brood of certain strains of bees is immune, but there is no evidence upon which to base this assumption. There may be various strains of the disease, differing in virulence, and individual colonies may react differently. Not enough variation has yet been detected, however, to warrant giving such suspected cases special treatment. Worker larvae are particularly susceptible to the disease, although queen and drone larvae are occasionally affected. Adult bees are immune to it.

CAUSE OF THE DISEASE

American foulbrood is caused by a species of spore-bearing bacteria known as *Bacillus larvae*. The living honeybee larva is its only known host and the disease is transmitted primarily by means of the spores. The bees that work within the hive become contaminated with these spores in attempting to remove the diseased brood, and carry them from one cell to another. Once the disease has spread generally throughout the brood nest, the bees cease trying to remove the dead brood, and it accumulates until the colony dies owing to the absence of emerging bees.

In performing such tasks as feeding the larvae, building the cells, ripening the nectar, and transferring it from one part of the hive to another, the bees may contaminate not only honey that is in the brood nest, but also that in the supers above the queen excluder. This does not mean, however, that all the honey in the brood nest or supers necessarily becomes contaminated.

Spores may come in contact with larvae of any age, but the larvae rarely die until they have developed to the point where they lie lengthwise in the cells or the cells are being sealed preparatory to transformation to pupae. During the early coiled stages the sugar content of the larva is usually high and, since the germ of American foulbrood will not grow in highly concentrated sugar or honey, it is only after much of the body sugar has been utilized that the spores can develop. Underfed larvae have a low sugar content, and in contact with such larvae the spores are able to germinate and to kill the larvae while they are still coiled.

The spores of American foulbrood are invisible to the naked eye, and they are extremely resistant to sunlight, drying, heat, and commonly used chemical disinfectants. The maximum time that the spores retain their virulence has not been determined, but they are known to remain alive for years in honey and brood combs.

SPREAD OF THE DISEASE

It has always been considered that the disease is spread from colony to colony most commonly by the robbing of hives containing disease-weakened colonies or bees that have died of American foulbrood, by bees from healthy colonies. Robbing unquestionably scatters American foulbrood. A disease-weakened colony does not defend itself well; therefore it is possible for robber bees from healthy colonies to help themselves to contaminated honey. On the other hand, the beekeeper himself often unwittingly spreads the disease within an apiary when he moves combs of brood and honey from one hive to another, or unites weak colonies, which may be diseased, with strong, healthy ones. These are probably the most common means of spread. The disease may also be carried from one colony to another when bees enter the wrong hive, a practice generally referred to as drifting.

The dissemination of the disease beyond the range of flight of the bee can be accounted for by the transportation of infected material, including honey, into a disease-free area, where it is later made accessible to healthy bees. Experimental evidence indicates that the commercial shipment of honey is not such an important means of spread as many persons suppose. The sale of used, contaminated equipment is, however, one of the principal avenues through which this disease is spread from one locality to another.

A beekeeper who does not know anything about American foulbrood, or how to check its spread in his apiary, will not be able to maintain his colonies with profit if they become weakened by the disease. Finding this to be the case, he may sell his empty hives, combs, and other accessories, perhaps to another beekeeper who knows no more about the bee diseases than he does. Purchasers of

used beekeeping equipment should make sure that it is free from disease material. Some States wisely restrict the sale of used beekeeping equipment to that which is known to be uncontaminated.

SYMPTOMS

In the apiary American foulbrood can be detected only by the presence of brood remains. The spores of the disease organism can be recovered and identified only by bacteriological technic.

The disease may be recognized by the sunken and perforated cappings and the isolated scaled cells in the midst of recently emerged brood. The dead larvae have a melted-down appearance and are usually extended lengthwise in the cells (fig. 1). Occasionally the bees die while in the coiled stage, and in this condition the brood may resemble that dead of European foulbrood. Dead larvae are slightly yellowish or dirty white in color at first, but become chocolate brown or black upon further decay. Shortly after death of the larvae, and until the contents of the cells become too thick, the brood remains can be drawn out with a toothpick into fine silklike threads, and are quite ropy and gluelike. Upon drying, the brood remains, called scales (fig. 1, F, G), become tough or brittle and adhere so tightly to the floor and base of the cells that the bees cannot remove them. The scales are very thin and in old, dark brood combs are easily overlooked.

Pupae that die of the disease undergo similar changes in color and consistency and in the final formation of a scale (fig. 2). Occasionally the tongue of a dead pupa adheres to the roof of the cell. This is a significant, but not an infallible, symptom.

Bees remove many of the cappings from cells containing dead brood, and this makes it appear that the larvae or pupae died before being sealed.

American foulbrood has a characteristic odor, which is pronounced when the disease is in an advanced stage.

Although adult bees are not attacked, loss of brood causes an infected colony to become gradually weaker, and usually to die during the second year of the disease.

The constancy and the uniformity of the symptoms characterize this disease more than does any one symptom. Isolated sealed, sunken, or perforated cells in the midst of healthy emerging brood should be examined whenever disease is suspected. It is not difficult to make a reliable diagnosis in the apiary except perhaps when only 1 or 2 recently dead larvae or pupae are present. In such cases a portion of the comb containing the suspected brood should be sent to a competent inspector. In the meantime the entrance of the suspected hive should be contracted and the colony left undisturbed until the nature of the trouble has been determined.

OTHER BROOD DISEASES SOMETIMES MISTAKEN FOR AMERICAN FOULBROOD

Many colonies have been destroyed or treated in the erroneous belief that they were infected with American foulbrood. On the other hand, the disease has been spread when American foulbrood

FIGURE 1.—Stages in the decomposition of larvae (prepupae) dead of American foulbrood: *A*, Healthy larva at the age when most of the brood dies of American foulbrood. *B*, *C*, *D*, *E*, Progressive stages in the decomposition of dead larvae. These stages can usually be detected only by removing the cappings. *F*, Scale of American foulbrood. Except in new combs the scale is difficult to see by looking straight into the cell. The comb should be held so that the line of sight falls on the long floor of the cells. This can be done by grasping the comb by the top bar and holding it 8 or 10 inches below the eyes and tipping the bottom bar slightly away from you. *G*, Longitudinal view of an American foulbrood scale.

has been mistaken for some of the less serious brood diseases, which require different treatment. It is therefore of the utmost importance that a correct diagnosis be made before corrective measures are applied. For this reason brief descriptions are here given of the

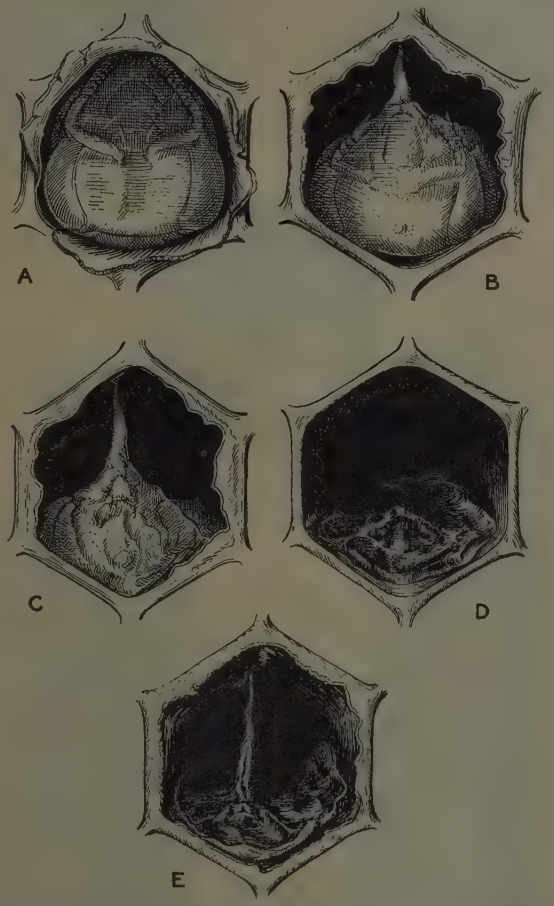

FIGURE 2.—Stages in the decomposition of pupae dead of American foulbrood: *A*, *B*, *C*, Heads of pupae showing progressive stages of melting down and decay. In *B* and *C* the tongues show prominently. *D*, Scale of American foulbrood formed from the drying down of a diseased pupa. *E*, Scale of American foulbrood formed from the drying down of a diseased pupa, with a vestige of the tongue adhering to the roof of the cell.

two other common brood disease of the apiary, European foulbrood and sacbrood.

European foulbrood usually kills the larvae in the coiled stages (fig. 3). The dead larvae are slightly yellowish white in color. The brood remains are watery, pastelike, or granular, the appearance varying according to the age at which the larvae die. The scales

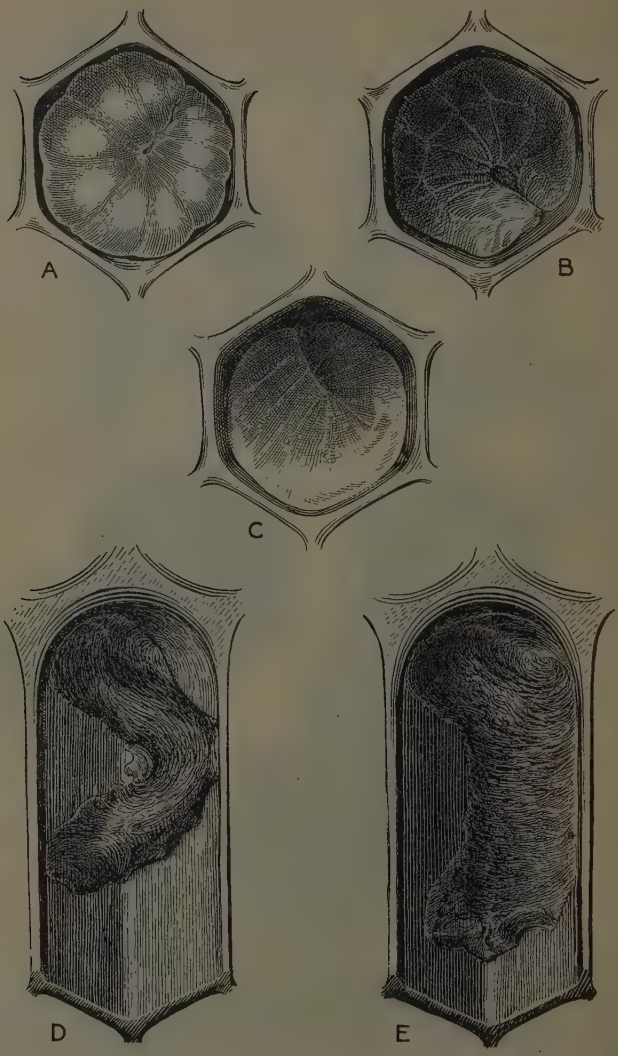

FIGURE 3.—Coiled and unsealed larvae sick or dead of European foulbrood: *A*, Healthy coiled larva at the earliest stage at which larvae die of European foulbrood; *B*, scale formed by a dried-down larva; *C*, one of several positions assumed by a sick larva prior to death; *D*, *E*, longitudinal views of scales formed from larvae that had assumed a nearly lengthwise position at the time of death, quite different from the scale shown in *B*.

do not adhere tightly to the cells and are removed by the bees in a strong colony. Occasionally larvae dead of European foulbrood become brown and ropy and present other symptoms similar to those

dead of American foulbrood (fig. 4). In such cases a correct diagnosis can usually be made only after a microscopic examination.

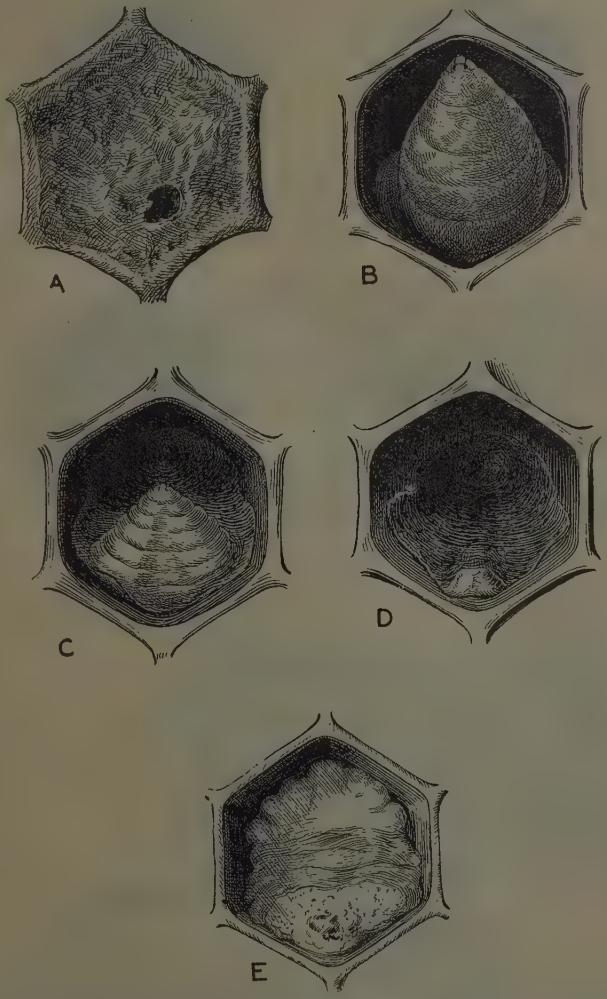

FIGURE 4.—Larvae (prepupae) which may or may not be in sealed cells and which are lying lengthwise at the time of death from European foulbrood. Stages similar in appearance to those illustrated here are encountered in American foulbrood. *A*, Sunken and perforated capping of a cell containing a larva dead of European foulbrood; *B*, larva lying lengthwise in the cell and recently dead of European foulbrood; *C*, same as *B* except in a more advanced stage of decomposition; *D*, scale formed by dried-down larva dead of European foulbrood; *E*, the remains of a larva dead of European foulbrood, part of which has been removed by the bees.

Sacbrood kills the larvae while they are extended in the cell (fig. 5), and the cappings become sunken and perforated, as in American foulbrood. The dead larvae are yellowish at first, but become

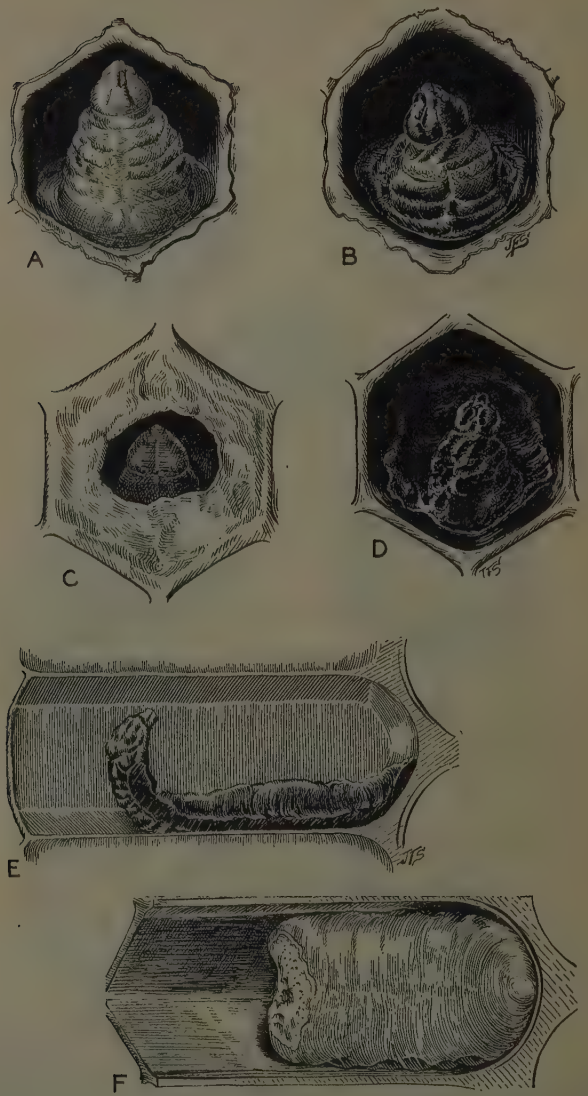

FIGURE 5.—Appearance of larvae (prepupae) dead of sacbrood: *A*, *B*, Stages in the course of the disease; *C*, the erect head end of a dead larva showing through an opening that the bees have made in the capping; *D*, *E*, two views showing the scale of sacbrood; *F*, the head portion of this larva has been gnawed away by the bees. Note how the head remains erect in all stages.

brown or black as decay advances. The heads remain erect during the process of decay. The larval skin becomes tough and saclike, thus giving the disease its name, and the material inside is watery and granular. The brood remains do not adhere to the cells; therefore, the bees are able to remove them and the disease does little damage.

TREATMENT

BURNING DISEASED COLONIES

It is now commonly recognized that the safest, and in the end the most economical, means of stamping out American foulbrood is to burn the diseased colonies. While this procedure may seem wasteful to those who believe that less drastic measures afford ample protection, it is the only method that leaves no opportunity for the disease to recur, thus relieving the mind of the beekeeper.

FIGURE 6.—Killing the bees of a diseased colony with calcium cyanide.

Diseased colonies should be burned as soon as possible after the infection is discovered. Before this is done, however, the bees must be killed. A tablespoonful of calcium cyanide, an extremely poisonous chemical which must be handled with great care, spread on a sheet of paper or cardboard and slipped into the entrance of the hive (fig. 6), which should be left open, will kill the bees in a few minutes. As as an extra precaution additional cyanide may be thrown into the top of the hive, since occasionally the bees fall onto the poison placed in the entrance so rapidly as to prevent the fumes from penetrating all parts of the hive. All field bees that try to gain entrance to the hive will also be killed.

Gasoline is sometimes used to kill the bees. In such cases the entrance to the hive is closed, a pint or more of gasoline is then poured over the top frames, and the hive is closed tightly.

After the bees have been killed, the contents of the hive should be burned with the least possible delay in order to avoid trouble

from robber bees, as both calcium cyanide and gasoline act as repellents for only a short time.

Before the bees are killed, a pit 18 inches or more deep, and wide enough to hold all the material to be burned, should be dug in a place not likely to be plowed or otherwise disturbed. A hot fire should then be kindled, with plenty of scrap material and with cross members stout enough to support the weight of the frames and placed so as to permit plenty of ventilation underneath. A brisk hot fire is necessary thoroughly to burn the brood and honey.

The hives containing the dead bees should be carried intact close to the pit and the bees and frames fed to the fire as fast as circumstances permit. The bottom board, hive bodies, inner covers, and tops are not burned. By placing the hives on pieces of burlap or stout paper it will be easy to gather up and burn the bits of comb honey or dead bees which may be dropped during the operation. After everything has been completely burned, the topsoil surrounding the fire should be raked into the pit to prevent bees from healthy colonies from having access to any dead bees or honey. The pit should then be filled.

If the killing of the bees and the burning are done at night, the danger of interference from robber bees will be lessened. It is essential, of course, to have everything well planned and all necessary material at hand.

No beekeeper should wait for an inspector to discover and burn his infected colonies, but should, himself, periodically inspect all colonies and promptly destroy every diseased one.

It should be understood that the burning of all diseased colonies in an apiary gets rid only of the colonies in which American foulbrood in an active form is plainly manifest. If there has been any equalization of the brood, if supers or combs have been transferred from one colony to another, or if diseased colonies have been robbed out, it is highly probable that the disease will show up later in other colonies. So even where burning is done carefully and thoroughly, it is usually at least 3 or 4 years before the disease can be stamped out of an apiary.

DISINFECTING EMPTY HIVES AFTER BURNING

After the burning, the hive bodies, bottom boards, inner covers, and tops should be taken into the honey house, thoroughly scraped to remove all propolis and wax, and then scrubbed, both inside and out, with a hot soap or lye solution and a stiff brush. The scrapings should be burned and the wash water disposed of in such a manner that it is not accessible to the bees.

Washing with soap and water is also the best way to remove spores from the hands, clothing, tools, and extracting equipment. Disinfectants strong enough to kill the spores are injurious to the hands.

If it is not feasible to wash the hive bodies, they may be stacked 7 or 8 high to form a chimney, the inside walls sprinkled with kerosene, and ignited. A little ventilation and fuel at the bottom of the stack will produce a hotter fire. Gasoline can also be used for this operation, but extreme precaution is necessary. As soon as the inside is scorched, the fire should be smothered by placing a board

over the top super. The outside of the hive bodies should then be thoroughly washed to remove all traces of honey. A gasoline blowtorch is a handy tool for scorching, but its use is rather slow.

SHAKING NOT RECOMMENDED

For many years the Department of Agriculture recommended the treating of infected colonies by the shaking method, whereby the bees in a diseased colony are shaken from the old combs into a clean hive on clean frames. This procedure reduces the losses due to the disease, and a careful operator, who thoroughly understands the disease, may be able to maintain his apiaries in this way. The disease is rarely eradicated by this method, however, and it usually has to be adopted as a routine manipulation. Treated colonies have to be nursed along, and the very act of shaking, if not done with meticulous care, is apt to spread the disease. Moreover, there is always a doubt as to whether the shaking is successful. A treated colony or a colony on disinfected combs cannot be pronounced clean for 2 years. Now, after many years during which colonies have been shaken to get rid of the disease and at the same time save as much as possible in the way of bees and equipment, the disease situation in the United States has not materially improved.

OBJECTIONS TO THE USE OF DISINFECTING SOLUTIONS

Disinfecting solutions are of only limited value in the treatment of American foulbrood. In the first place, their use for treating brood combs does not obviate the shaking treatment, as the bees must be removed before the combs are disinfected. Moreover, the careless handling of combs during the disinfecting operation may result in failure. When disease reappears after a colony has been shaken and later placed on treated combs, it is impossible to tell whether the method of shaking was at fault, the disinfection inadequate, or the colony reinfected.

Although there are several disinfectants which, when properly used, will kill the spores of American foulbrood without destroying the comb, none has yet been found to sterilize the spores in sealed honey without destroying the comb and making the honey poisonous to bees and brood. Individual sealed cells are easily overlooked and it is probable that many, if not most, of the cells of honey in the brood chamber of a diseased colony are contaminated.

Another disadvantage in the use of disinfectants is that bees are loath to accept treated combs, and as a result the size of the honey crop is reduced.

DISINFECTING SUPER COMBS

Disinfectants can be used effectively in treating super combs that have never contained brood. Super combs are ordinarily used on whatever colony needs them and are not set aside for designated colonies. After all the diseased colonies in an apiary have been disposed of, it is often not possible to know whether any of the general supply of super combs have become contaminated by being used on colonies with foulbrood. Therefore, it is safest to disinfect all the super combs in an outfit in which there has been appreciable

amount of American foulbrood. This is the only use recommended for disinfecting solutions in connection with the treatment of this disease.

Super combs can be disinfected with a 20 percent formalin-water solution—that is, 20 parts of formalin[1] to 80 parts of water, liquid measure. The combs to be disinfected should be free of honey. They should be kept immersed in the solution at a temperature of not less than 70° F. for at least 24 hours. At lower temperatures sterilization proceeds much more slowly. In order that the solution may come in contact with all parts of the cells, after being placed in the solution the combs should be agitated to dispel as many air bubbles as possible. This can also be accomplished by pouring the solution into the tank so that it rises slowly enough to fill each cell completely.

The 20 percent formalin-water solution may be used repeatedly without much deterioration in strength. It is advisable, however, to add formalin occasionally to maintain full strength of the solution.

Formalin is unpleasant to work with, although not dangerous. It is well for the operator to protect his hands with rubber gloves.

Formalin-alcohol solution, formaldehyde gas, and chlorine also kill the spores of American foulbrood without necessarily destroying the combs. Formalin-alcohol solution, a patented article, is slightly less effective than the 20 percent formalin-water solution and is more expensive. Formaldehyde in gaseous form cannot be recommended for treating American foulbrood combs. The use of chlorine, although still in the experimental stage, has produced disappointing results and, moreover, it is extremely dangerous to handle.

TREATMENT BY STATE INSPECTORS

Under most conditions inspectors are justified in burning every diseased colony immediately, because such a colony constitutes a menace to all healthy colonies in the vicinity. The maintenance of such a serious nuisance as a colony containing American foulbrood should not be tolerated. The best interests of the industry demand the prompt disposal of all such colonies.

When a State inspection force is applying the area-clean-up method for the first time, however, and when the incidence of the disease is high, the use of the shaking treatment is sometimes justifiable. The advisability of using it depends not only upon the amount of disease in a particular apiary or area, but upon the character of the beekeeping, the kind of equipment employed, and the facilities and experience of the beekeepers for doing the job.

Where shaking is used in the first steps of an eradication program, the State inspectors should give every consideration to the protection of healthy colonies. The establishment of temporary yards where diseased colonies can be treated without endangering healthy colonies is strongly recommended in this connection. These temporary yards are not to be confused with hospital yards, which were recommended at one time and with which many beekeepers are

[1] Formalin or formaldehyde solution is an aqueous solution containing from 37 to 40 percent of formaldehyde gas.

familiar. Temporary yards are used only to shake and reestablish the bees in a place where healthy colonies are not endangered. The contents of the hives other than bees should be burned with the least possible delay.

HANDLING AND DISPOSING OF HONEY FROM AFFECTED COLONIES

The honey from a diseased colony, if it constitutes a super or more, may be saved and marketed. The handling of this honey, however, requires special attention. At no time should it be accessible to the bees. Therefore, since no honey house is, strictly speaking, bee-tight, the honey should be bottled or canned as soon as possible, every vestige of honey washed from the outside of containers and from the extracting equipment and honey house, and the empty combs burned. No attempt should be made to recover honey from diseased colonies unless there is a distinct economic saving.

Since it is often impossible to ascertain the source of honey purchased on the open market, such honey should not be fed to colonies of bees if it can be avoided. If such honey has to be used, it should first be diluted with an equal volume of water and boiled for an hour in a closed vessel. Boiled honey, however, should not be fed for winter stores.

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U. S. GOVERNMENT PRINTING OFFICE: 1933

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